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PERFORMANCE EVALUATION AND BIOLOGICAL TREATMENT OF DAIRY WASTE WATER TREATMENT PLANT BY UPFLOW ANAEROBIC SLUDGE BLANKET REACTOR

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ABSTRACT

In recent years due to the increase in the population, a high demand for the more efficient use of water resources and its reuse has tremendously changed in both urban & rural areas. The main objective of this study was to evaluate the removal efficiency & performance of effluent treatment plant in a diary industry in terms of COD, BOD, TSS, TDS, oil and grease, alkalinity, total hardness, chlorides and dissolved oxygen removal. An intensive analytical programme was followed for 6 months for monitoring dairy wastewater. Samples of wastewater were collected from the effluent treatment plant from the dairy for the characteristic analysis. This study revealed that average concentrations of COD, BOD, TSS, TDS, oil and grease, alkalinity and chlorides removal in the effluent from the effluent plant were 155 mg /l, 85 mg /l, 34.5 mg/l, 661 mg/l, 6.3 mg/l, 7.05 mg/l and 81 mg/l respectively, which met the effluent standards for all the above described parameters. The efficiency of treating dairy wastewater was studied and its performance was assessed by monitoring COD, BOD, TSS, TDS, oil and grease, alkalinity and chlorides removal .The reactor achieved COD, BOD, TSS, TDS, oil and grease and chlorides removal efficiency was observed as 77.0 %, 87.0 %, 47.1%, 57.0 %, 92.0 % and 49.8 % respectively. The data presented also revealed that the order of efficiency was TSS < chlorides < TDS < COD < BOD < oil & grease.

KEYWORDS: Effluent, Efficiency, Concentrations, Dairy Wastewater, Performance

INTRODUCTION

The dairy industry involves processing raw milk into products such as consumer milk, butter, cheese, yogurt, condensed milk, dried milk (milk powder), and ice cream, using processes such as chilling, pasteurization, and homogenization. Typical by-products include buttermilk, whey and their derivatives (World Bank. 1998).

Normally, in almost all the diary industries water has been a key processing medium used for different processes like cleaning, sanitization, heating, cooling, floor washing, which directly implies that the requirement of water is huge, hence giving rise to large amount of waste waters produced which is estimated to be 2% of the total milk production which is wasted into drains. Also, dairy effluents contain dissolved sugars and proteins, fats, and possibly residues of additives (Jai Prakash Kushwaha, 2011).The key parameters are biochemical oxygen demand (BOD), with an average ranging from 0.8 to 2.5 kilograms per metric ton (kg/t) of milk in the untreated effluent; chemical oxygen demand (COD), which is normally about 1.5 times the BOD level; total suspended solids, at 100–1,000 milligrams per liter (mg/l); total dissolved solids: phosphorus (10–100 mg/l), and nitrogen (about 6% of the BOD level). Cream, butter, cheese, and whey production are major sources of BOD in wastewater. The waste load equivalents of specific milk constituents are: 1 kg of milk fat = 3 kg COD; 1 kg of lactose = 1.13 kg COD; and 1 kg protein = 1.36 kg COD. The wastewater may contain pathogens from

contaminated materials or production processes. A dairy often generates odors and, in some cases, dust, which need to be controlled. Most of the solid wastes can be processed into other products and byproducts. (Stephania Iordache et al., 2009)

Pretreatment of effluents consists of screening, flow equalization, neutralization, and air flotation (to remove fats and solids); it is normally followed by biological treatment. If space is available, land treatment or pond systems are potential treatment methods. Other possible biological treatment systems include trickling filters, rotating biological contactors, and activated sludge treatment. Pretreated dairy effluents can be discharged to a municipal sewerage system, if capacity exists, with the approval of the relevant authority.

Hence effluent treatment plants are implemented by most of the leading industries through out the world, where different dairy wastes will be treated with different methods to purify wastewater & remove any toxic materials /chemicals from it, & reuse.

The main objective of this study was to determine the behavior of various parameters of the dairy wastewater. Characterization of wastewater was evaluated in terms of the performance of effluent treatment plant in terms of COD, BOD, TSS, TDS, oil and grease, alkalinity and chlorides removal from the selected plants. The performance of the effluent treatment plant was also evaluated & the quality of the reclaimed wastewater was compared with Karnataka State Pollution control Board (KSPCB) standards to determine its suitability for reuse.

MATERIALS AND METHODS

The source for the collection of wastewater samples throughout the present studies was the Diary industry located in Bangalore, Karnataka. Raw wastewater samples were collected at random from industrial dairy plant. This dairy plant manufactures a variety of dairy products in a semi hydrated or dehydrated form (i.e., butter, ghee, sweetened milk and milk powders) where technological wastewater is a mixture of two streams coming from various processing units. Effluent will be allowed to pump into the fat removal unit, after removal of fats both the streams are equalized in equalization tank and then it is supplied to the anaerobic digester (UASB) & then to the extended aeration tank (aerobic digestor tank)& finally into the clarifiers.

Present research study was conducted for a period of 6 months The parameters of raw wastewater samples were determined in accordance to Karnataka state pollution control board limits and these were of COD, BOD, TSS, TDS, oil and grease, alkalinity and chlorides . Also performance of the effluent treatment plant was also evaluated & the quality of the reclaimed wastewater was compared with Karnataka State Pollution control Board (KSPCB) standards.

RESULTS AND DISCUSSIONS

Data taken during 6 months of this study are presented and discussed. The nature of the waste water from dairy industries varies through out the working day. The Concentration of these pollutants should not be allowed to go beyond a certain range according to the KSPCB Standards, and extra care should be taken to avoid shock load.

Treatability Study using Biological Method (UASB & Aerobic Digester Tank)

Dairy wastewater was anaerobically treated by biological method using Upflow Anaerobic Sludge Blanket (UASB) reactor, which was followed by the treatment using aerobic biological process. The waste water samples collected from both the inlet and outlet of waste water processing unit was analyzed to obtain seasonal variation in the different

parameters concentration in the waste water. The test was performed for different time slots to explore the efficiency & performance of the effluent treatment plant.

Analysis of Sample

The samples were analyzed for the following parameters:

pH: pH is the measure of the intensity of acidity or alkalinity and measures the concentration of the hydrogen ions in the water. Each samples pH was measured immediately after its collection by a pH meter. The results are shown in Table 1 and 2. The inlet pH of UASB tank ranged from 7.65 to 7.9, outlet pH ranged from 6.9-7.2, with an average value ranging from 7.77-7.05 mg/l from January to June. Similarly for the extended aeration tank, inlet pH of the tank ranged from 6.9 to 7.2, outlet pH ranged from 6.8-7.1, with an average range of 7.05-6.95 for the period January to June. Extremes values of pH of wastewater are generally not acceptable as extremes of pH cause problems to survival of aquatic life. It also interferes with the optimum operation of wastewater treatment facilities. Water with high or low pH is not suitable for irrigation. At low pH most of the metals become soluble and become available and therefore could be hazardous in the environment. At high pH most of the metals become insoluble and accumulate in the sludge and sediments. The findings of the present study are in agreement with the KSPCB standards (Table 3).

Total Suspended Solids (TSS): TSS are solid materials, including organic and inorganic, that are suspended in the water sample. Total suspended solids play a major role in water and waste water treatment. High concentrations of suspended solids can lower water quality by absorbing light, hence causes depletion of oxygen level in the water sample.

The TSS at the inlet of UASB tank ranged from 109-148 mg/l, at the outlet TSS ranged from 54-78 mg/l, with an average value of 125-66 mg/l from January to June as shown in figure 2. Similarly for the extended aeration tank, inlet TSS of the tank ranged from 54-78 mg/l, outlet TSS ranged from 22-45 mg/l, with an average range value from 66-34.5 mg/l which were in accordance with the KSPCB standards (Table 3). Fig.4 shows the variation in TSS at the outlet of extended aeration tank & also the TSS removal varied between 41-66 % & the mean value of performance of the tank was found to be 47.08 %.

Total Dissolved Solids (TDS): Although TDS is not generally considered a primary pollutant since it is not deemed to be associated with health effects; it is used as an indication of aesthetic characteristics of drinking water and as an aggregate indicator of the presence of a broad array of chemical contaminants. Dissolved solids refer to any minerals, metals, cations or anions dissolved in water.

The BOD, COD and TDS values are shown in the Table 1 and 2 . The values ranges within 2632 -3900 (before entering the UASB tank) 1352-2230 and mg/l (after leaving the UASB tank) with an average value range of 3151- 1819 mg/l from January to June which is as represented in figure 1. Similarly for the extended aeration tank, inlet TSS of the tank ranged from 1352-2230 mg/l, outlet TDS ranged from 322-1031mg/l, with an average value ranging from 1819-661 mg/l which were well within the maximum permissible limits of 2100 mg/l in accordance with the KSPCB standards (Table 3). Fig.3 shows the variation in TDS at the outlet of extended aeration tank & also the TDS removal varied between 54-71 % & the mean value of performance of the tank was 56.6 %.

Chemical Oxygen Demand (COD): Chemical oxygen demand (COD) is used as a measure of oxygen requirement of a sample that is susceptible to oxidation by strong chemical oxidant. The COD is a test which is used to

measure pollution of domestic and industrial waste. The dichromate reflux method is preferred in our study to determine the COD values for waste water samples.

For COD determination samples were preserved using H_2SO_4 or H_3PO_4 and processed for COD determination after the entire sampling operation was complete. The results are shown in Table 1 and 2. As compared to BOD, COD was very high which is normal for such diary industries. The inlet COD of UASB Tank ranged between 1090-1415 (before entering the tanks) and 450-824.8 mg/L (after leaving the tank). The averaged values ranged between 853-415 mg/l for both the influent & the effluent from January to June which is as shown in figure 1. Similarly for the extended aeration tank, inlet COD of the tank ranged from 450-824.8 mg/l, outlet COD ranged from 130-180 mg/l, with an average range value from 415-155 mg/l which were in accordance with the KSPCB standards (Table 3). Fig.3 shows the variation in COD at the outlet of extended aeration tank & also the COD removal varied between 71-82 % & the mean value of performance efficiency of the tank was found to be 76.9 %.Our study showed that the average COD after treatment of wastewater was found to be 155 mg/L which was well within the maximum permissible limits of 250 mg/L according to KSPCB standards (Table 3).

Biochemical Oxygen Demand (BOD): For determining BOD_5 samples were immediately processed after Collection for the determination of initial oxygen and incubated at 20 °C for 5 days for the determination of BOD_5. The results are shown in Table 1 and 2, Figure 3. The minimum and maximum values for UASB tank ranged from 1015-1370 (before entering the tanks) and 438.4-830 mg/L (after leaving the tanks). The averaged values ranged between 1212-678 mg/L for both the influent & the effluent from January to June which is as represented in figure 1. Similarly for the extended aeration tank, inlet BOD of the tank ranged from 438.4-830 mg/l, outlet BOD ranged from 62-98 mg/l, with an average range value from 678-85 mg/l, where the average value of BOD after the treatment of effluent was found to be 85 mg/l which was well within the maximum permissible limits of 100 mg/L according to KSPCB standards (Table 3). Fig.3 shows the variation in BOD at the outlet of extended aeration tank & also the BOD removal varied between 81-91 % & the mean value of performance efficiency of the tank was found to be 86.6 %. In literature, the BOD_5 removal efficiency of anaerobic pond is 50-70% (Mara, 1976 cited in Ramadan and Ponce, n.d.: Online). Monali etal (2011) reported that 94.50% removal efficiency for the case of BOD using a UASB reactor for the treatment of dairy waste water.

Chlorides: Chlorides are generally present in natural water. The presence of chloride in the natural water can be attributed to dissolution of salts deposits discharged of effluent from chemical industries, oil well operations, sewage discharge of effluent from chemical industries, etc. In large concentrations chlorides cause a brackish, briny taste that definitely is undesirable.

The chlorides content at the inlet of UASB tank ranged from 295.5-345.5 mg/l, at the outlet it ranged from 105-203 mg/l, with an average value of 319-156 mg/l from January to June which is as represented in figure 2. Similarly for the extended aeration tank, inlet chlorides of the tank ranged from 105-203 mg/l, outlet chlorides ranged from 41-115 mg/l, with an average range value from 156-81 mg/l which were in accordance with the KSPCB standards (Table 3). Fig.4 shows the variation in chlorides at the outlet of extended aeration tank & also the chlorides removal varied between 40-64 % & the mean value of performance of the tank was found to be 50.0 %.

Oil & Grease: The effluent has the oil and grease present in the form of micro droplets or tiny suspended particles if the concentrations are low. Higher levels of the analytes in the sample commonly appear as an actual layer on top of the water. Hence in our study the partition – gravimetric method was involved where extraction of dissolved or

emulsified oil and grease from water by using an extracting solvent was performed to determine the amount of oil & grease present in the waste water samples & analyzed further to check the performance of the effluent treatment plant.

The minimum and maximum values for UASB tank ranged from 115.5-170 (before entering the tanks) and 55-102 mg/L (after leaving the tanks). The averaged values ranged between 152-80 mg/L for both the influent & the effluent from January to June which is as shown in figure 2. Similarly for the extended aeration tank, inlet oil & grease of the tank ranged from 55-102 mg/l, outlet oil & grease ranged from 5-9 mg/l, with an average range value from 80-6.3 mg/l, where the average value of oil & grease after the treatment of effluent was found to be 6.3 mg/l which was well within the maximum permissible limits of 10 mg/L according to KSPCB standards (Table 3). Fig.4 shows the variation in oil & grease at the outlet of extended aeration tank & also the oil & grease removal varied between 89-93 % & the mean value of performance efficiency of the tank was found to be 91.6 %.

Table 1: Physico-Chemical Parameters of Average Wastewater Influent & Effluent from the UASB Tank

Month of Sampling	Avg. TDS mg/l			Avg.COD mg/l			Avg. BOD mg/l		
	Influent mg/l	Effluent mg/l	% Efficiency	Influent mg/l	Effluent mg/l	% Efficiency	Influent mg/l	Effluent mg/l	% Efficiency
January	3900	2230	43.0	1330	805	40	1370	830	39.0
February	3885	2150	44.6	1360	824	39.3	1207	719	40.0
March	3115	1985	56.0	1250	658	47.3	1109	655	41.0
April	2652	1546	41.0	1415	790	44.1	1340	717	47.0
May	2724	1650	39.0	1120	590	47.3	1230	709	42.0
June	2632	1352	49.0	1090	450	59.0	1015	438	57.0

Month of Sampling	Avg. Chlorides mg/l			Avg.TSS mg/l			Avg. Oil & Grease mg/l			Avg. pH	
	Influent mg/l	Effluent mg/l	% Eff	Influent mg/l	Effluent mg/l	% Eff	Influent mg/l	Effluent mg/l	% Eff	Influent mg/l	Effluent mg/l
January	345.5	203	41.0	148	78	47.0	170	102	40.0	7. 83	7. 2
February	332.4	198	40.0	125	71	43.0	164.5	78	53.0	7. 80	7.1
March	295.5	164	45.0	117	67	51.0	169	98	42.0	7. 70	7.05
April	315.5	151	52.0	131	58	56.0	158	78	50.0	7. 74	7. 1
May	317.6	105	67.0	109	54	51.0	135.5	69	49.0	7. 65	6. 9
June	309.5	115	63.0	121	65	46.0	115.5	55	53.0	7. 90	7.1

Table 2: Physico-Chemical Parameters of Average Wastewater Influent & Effluent from the Extended Aerobic Digester Tank

Month of Sampling	Avg. TDS mg/l			Avg.COD mg/l			Avg. BOD mg/l		
	Influent mg/l	Effluent mg/l	% Efficiency	Influent mg/l	Effluent mg/l	% Efficiency	Influent mg/l	Effluent mg/l	% Efficiency
January	2230	1031	54	805	180	78	830	98	88
February	2150	945	56	824	161.5	80	719	85	88
March	1985	742	63	658	120.5	82	655	84	86
April	1546	543	65	790	168	79	717	97	86
May	1650	322	81	590	167	72	709	62	91
June	1352	385	71	450	130	71	438	85	81

Month of Sampling	Avg. Chlorides mg/l			Avg.TSS mg/l			Avg. Oil & Grease mg/l			Avg. pH	
	Influent mg/l	Effluent mg/l	% Eff	Influent mg/l	Effluent mg/l	% Eff	Influent mg/l	Effluent mg/l	% Eff	Influent mg/l	Effluent mg/l
January	203	115	43	78	45	42	102	9	92	7. 2	7.1
February	198	109	45	71	38	45	78	7	91	7.1	6.8
March	164	98	40	67	39	42	98	5	93	7.05	6.9
April	151	75	50	58	34	41	78	6	92	7. 1	7.0
May	105	45	57	54	29	46	69	5	93	6. 9	7.0
June	115	41	64	65	22	66	55	6	89	7.1	6.9

Table 3: Comparison between the Findings of the Present Study & the Standards of Waste Water Discharge Quality of the Treatment Plant

Parameter	Untreated Effluent According to KSPCB Standards	Untreated Effluent of the Treatment Plant	KSPCB Tolerance Limits for Treated Effluents for Urban Re-Use	Present Findings of the Treated Effluent Plant	Overall Percentage Efficiency of the Treated Effluent Plant
pH	6.3-8.3	6.9-7.9	6.0-9.0	6.8-7.1	------
TDS mg/l	275-1120	1352-3900	<2100	322-1031	54-71
TSS mg/l	200-720	54-125	<100	22-45	41-66
BOD mg/l	50-1900	438.4-1370	<100	62-98	81-91
COD mg/l	50-6000	450-1330	<250	130-180	71-82
Chlorides mg/l	50-350	105-345.5	<1000	41-115	40-64
Oil & grease mg/l	30-400	55-170	<10	5-9	89-93

Overall Efficiency of the Effluent Treatment Plant

This study investigated the treatment efficiency of wastewater treated in phases of the anaerobic and aerobic process (Table 4). The extended aerobic process gave better removal efficiency of high oil and grease of 92.0 %, COD of 77 % and BOD of 87% removal efficiency, where as anaerobic treatment showed 46 % COD removal whereas anaerobic phase has poor COD removal capacity of 44.3 % which is as shown in the Figure 5 & 6.The overall treatment showed good performance. Every treatment phase of this effluent treatment process (ETP) has its unique removal capacity, and the treated water of ETP met the effluent discharged standards of KSPCB.

Table 4: Efficiency of Wastewater of the Effluent Treatment Plant

Month of Sampling	Anaerobic Tank (UASB) Efficiency (%)						Extended. Aeration Tank Efficiency (%)					
	TDS	BOD	COD	TSS	Chlorides	Oil & Grease	TDS	BOD	COD	TSS	Chlorides	Oil & Grease
January	43.0	39.0	40.0	47.0	41.0	40.0	54.0	88.0	78.0	42.3	43.0	92.0
February	44.6	40.0	39.3	43.0	40.0	53.0	56.0	88.0	80.4	45.0	45.0	91.0
March	56.0	41.0	47.3	51.0	45.0	42.0	63.0	86.0	81.6	42.0	40.0	93.0
April	41.0	47.0	44.1	56.0	52.0	50.0	65.0	86.0	78.7	41.0	50.0	92.0
May	39.0	42.0	47.3	51.0	67.0	49.0	81.0	91.0	71.6	46.2	57.0	93.0
June	49.0	57.0	59	46.0	63.0	53.0	71.0	81.0	71.1	66.0	64.0	89.0

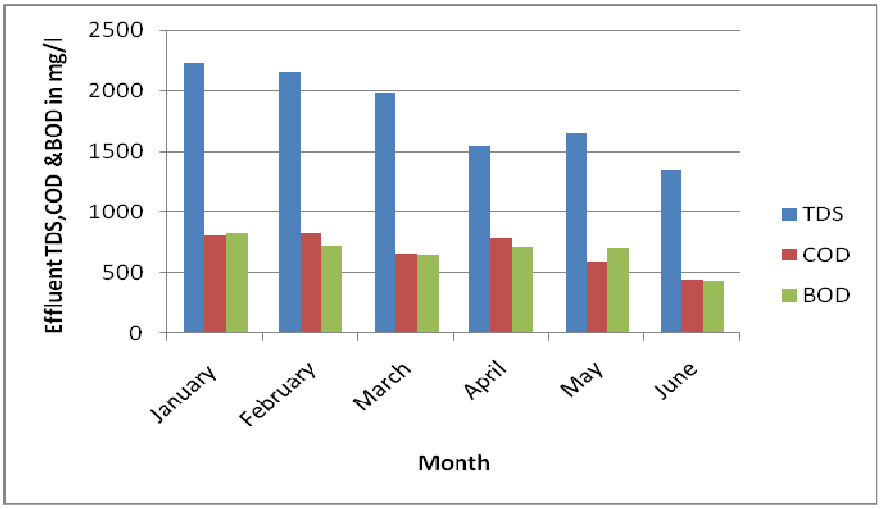

Figure 1: Comparison between Effluent TDS, COD & BOD in the UASB Tank

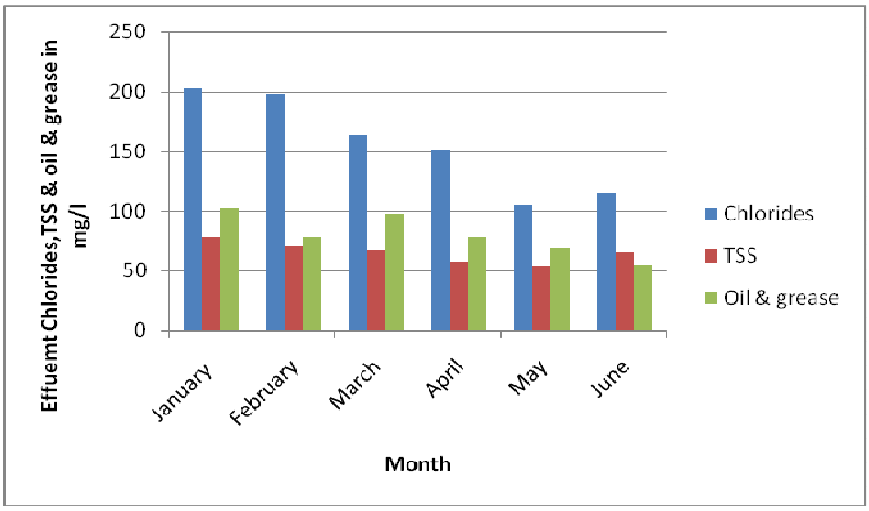

Figure 2: Comparison between Effluent TSS, Chlorides & Oil & Grease in the UASB Tank

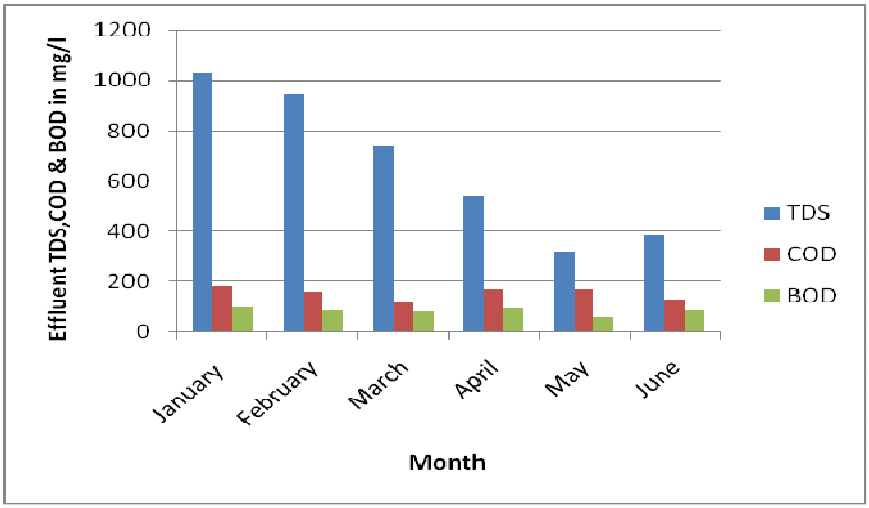

Figure 3: Comparison between Effluent TDS, COD & BOD in the Extended Aeration Tank

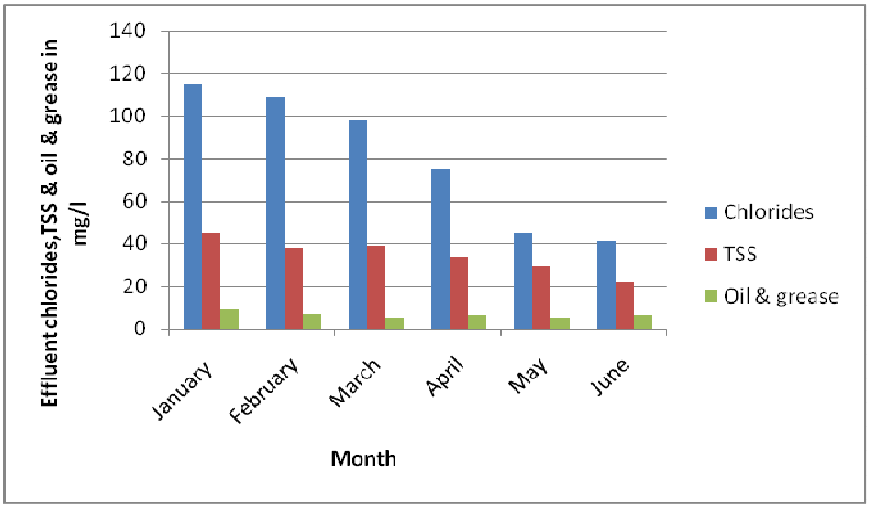

Figure 4: Comparison between Effluent TSS, Chlorides & Oil & Grease in the Extended Aeration Tank

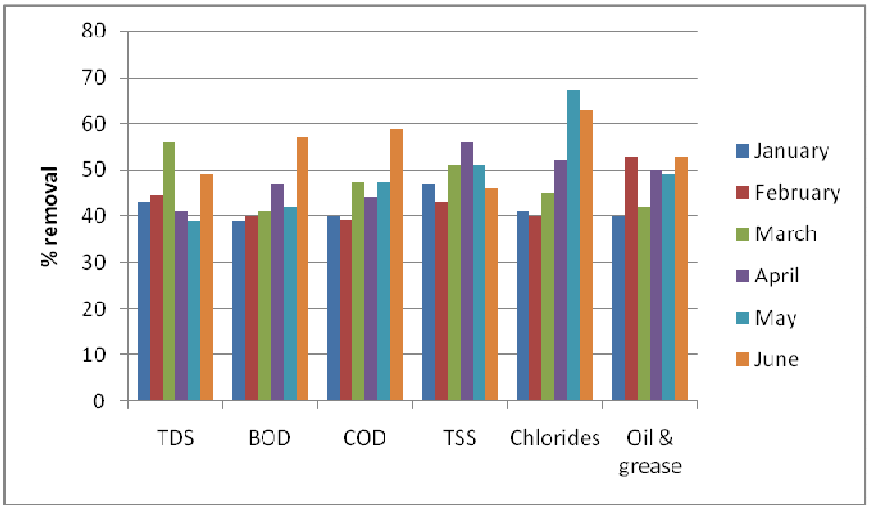

Figure 5: Reduction of Effluent TDS, BOD, COD, TSS, Chlorides & Oil and Grease in UASB Tank

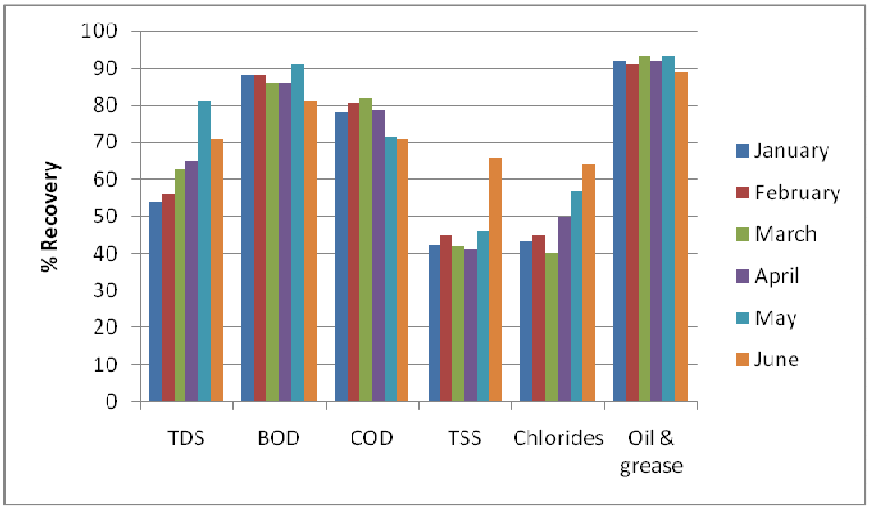

Figure 6: Reduction of Effluent TDS, BOD, COD, TSS, Chlorides & Oil and Grease in Extended Aeration Tank

CONCLUSIONS

The performance studies on the dairy wastewater treatment plant were evaluated. As per available 5 months data, existing effluent treatment plant appears to be capable of withstanding the shock loads without affecting the efficiency of the plant. The individual units are also performing well and their removal efficiencies are satisfactory. This study investigated the treatment efficiency of wastewater treated in phases of the anaerobic and aerobic process .The extended aerobic process gave better removal efficiency of high oil and grease of 92.0 %, COD of 77 % and BOD of 87% removal efficiency, where as anaerobic treatment showed 46 % COD removal whereas anaerobic phase has poor COD removal capacity of 44.3 % . The working condition of the UASB tank & extended aerobic tank was satisfactory, hence the overall treatment showed good performance. Thus this treatment Technology can be considered as a potential plant for industrial wastewater treatment.

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